Sensitivity of Tropical Cyclone Rainfall to Different Warming Scenarios

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Problem Statement and Objectives

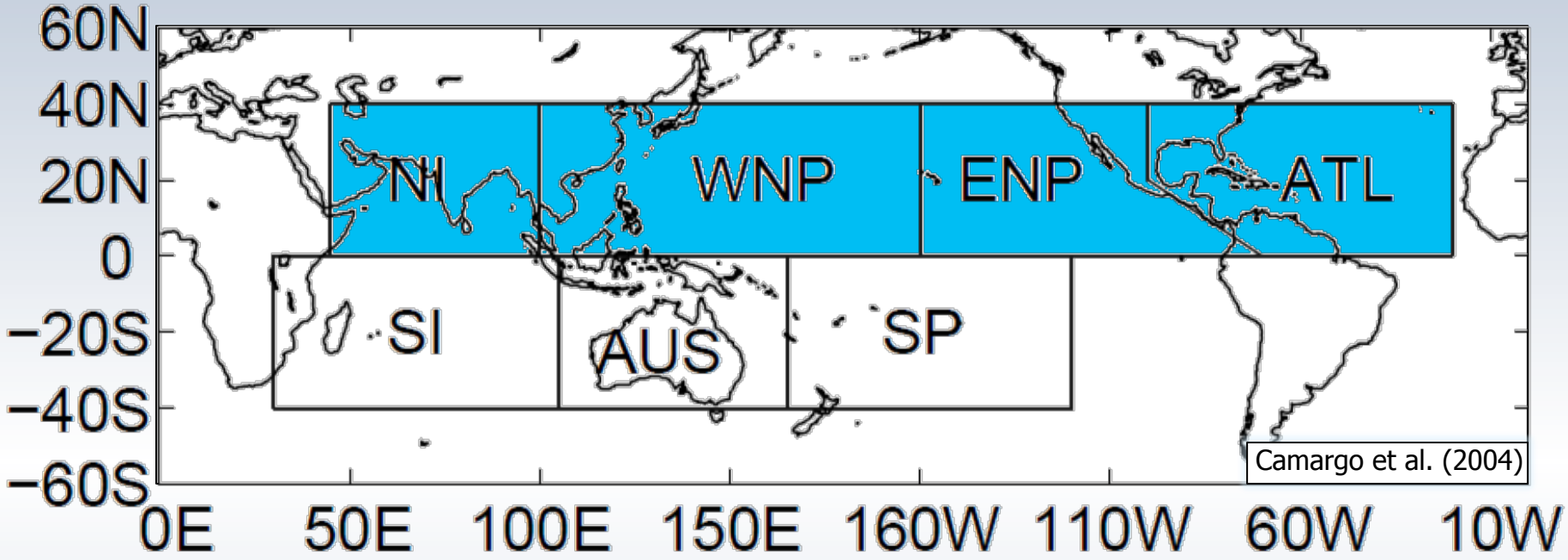
- Heavy rainfall and flooding associated with tropical cyclones are responsible for a large number of fatalities and economic damage
- Projected increases in tropical cyclone rainfall of up to 20% in a warmer climate
- Large regions vulnerable to flooding and heavy rainfall associated with tropical cyclones

Central Research Issues:

- sensitivity of tropical cyclone rainfall to different warming scenarios using model outputs from the U.S. CLIVAR Hurricane Working Group

- A data-driven assessment of the role of North Atlantic tropical cyclones as flood agents

Study Region and Scenarios



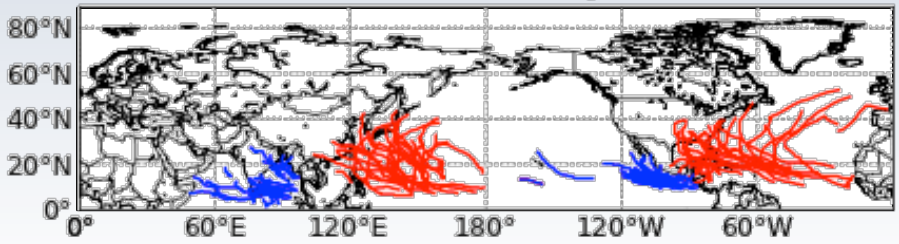
- Northern hemisphere (North Indian, western North Pacific, eastern North Pacific, North Atlantic)
- Two models (GFDL and CMCC)
- Four scenarios (Present Day, 2×CO_2, +2K, 2×CO_2+2K)
- Examination of the top-30 TCs for each model/basin/scenario

Climate Models

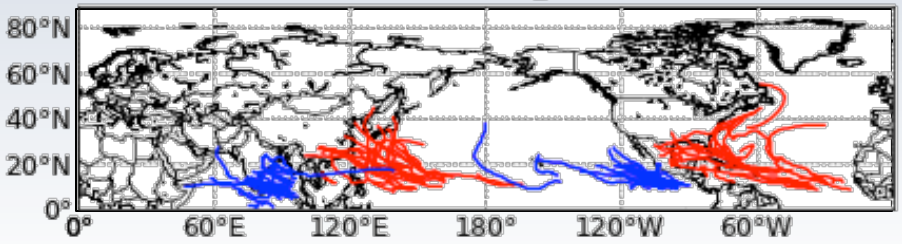
	GFDL	CMCC
	HIRAM	ECHAM5
Spatial resolution	50 km	80 km
Vertical levels	32	31
Precipitation parameterization	Bretherton et. al 2004, Rotstayn 1997, Rotstayn 2000.	Tiedtke 1989, modified following Nordeng, 1994.
Reference	Zhao, M., I.M. Held, S-J. Lin, and G.A. Vecchi, 2009: Simulations of global hurricane climatology, interannual variability, and response to global warming using a 50km resolution GCM, Journal of Climate, 33, 6653-6678.	Roeckner, E., and Coauthors, 2003: The atmospheric general circulation model ECHAM5. Part I: Model description. MPI Rep. 349, 127 pp.

GFDL Tracks

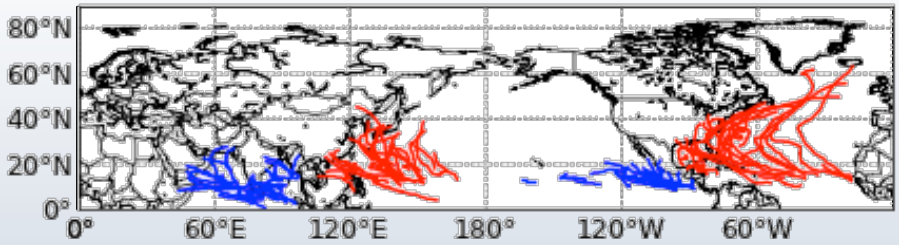
Present Day



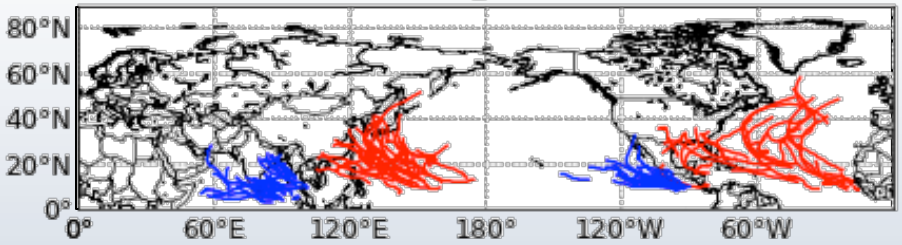
$2xCO_2$



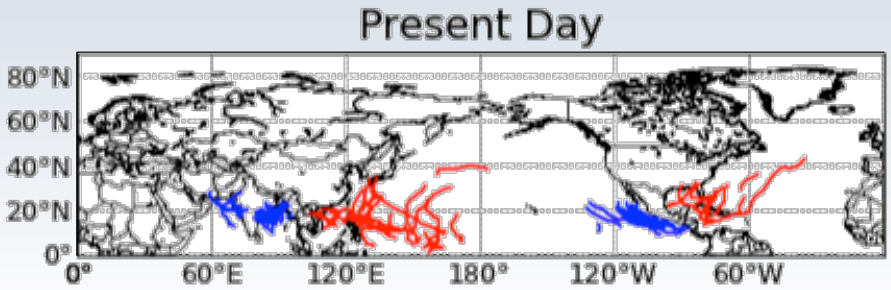
+2K

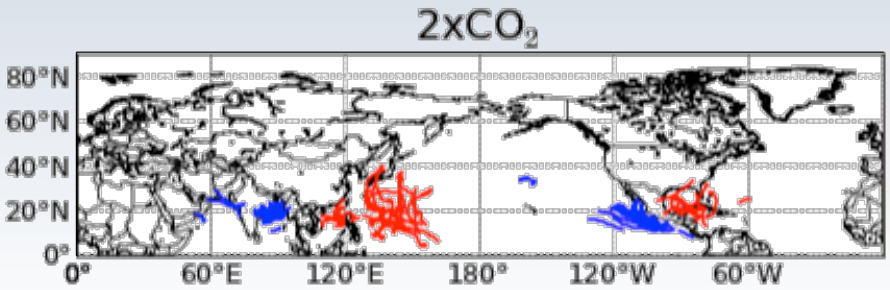


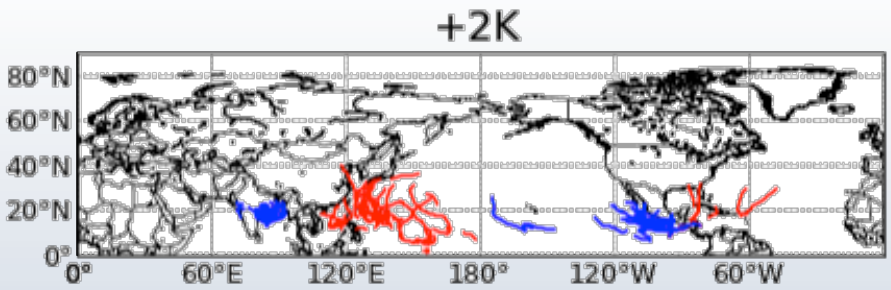
$2xCO_2$ + 2K

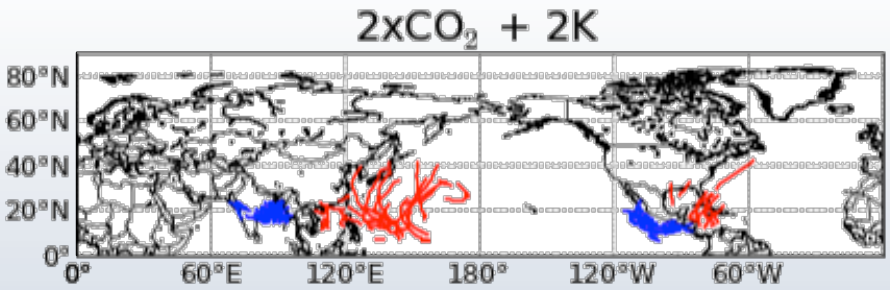


CCMC Tracks

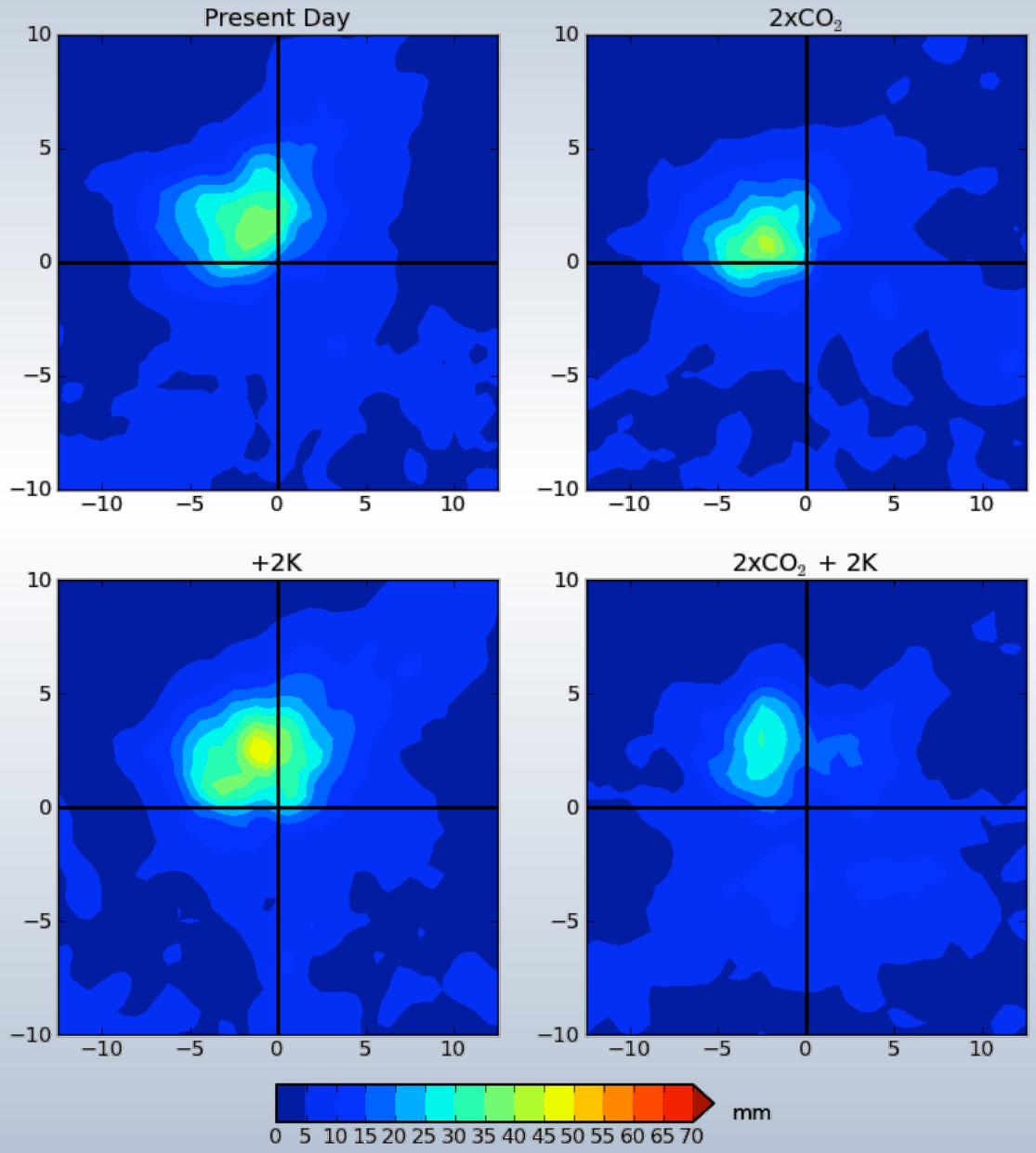

Present Day
80°N
60°N
40°N
20°N
0°
0°
60°E
120°E
180°
120°W
60°W


2xCO2
80°N
60°N
40°N
20°N
0°
0°
60°E
120°E
180°
120°W
60°W

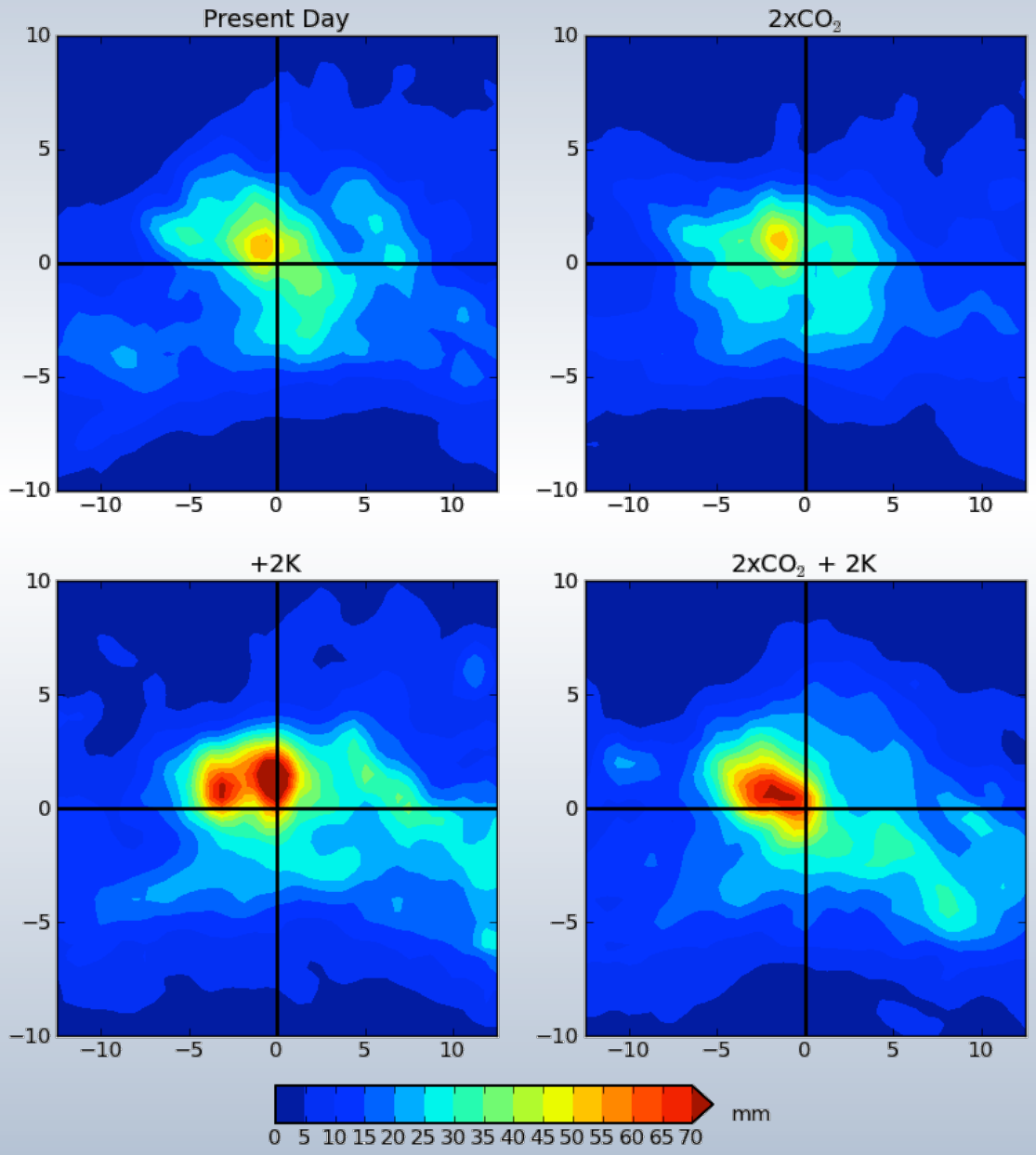

+2K
80°N
60°N
40°N
20°N
0°
0°
60°E
120°E
180°
120°W
60°W


2xCO2 + 2K
80°N
60°N
40°N
20°N
0°
0°
60°E
120°E
180°
120°W
60°W

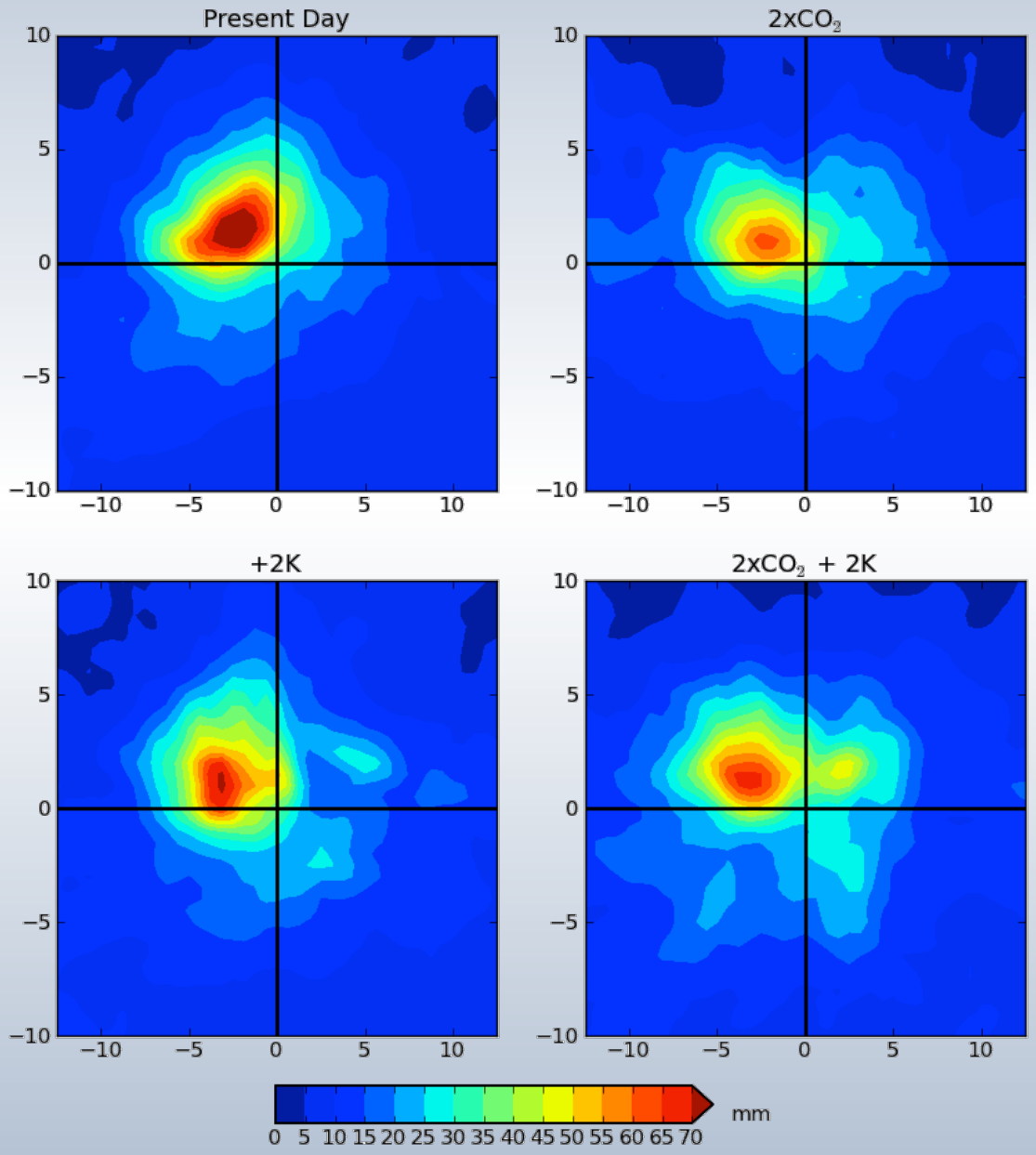
Rainfall Composite: GFDL (ATL)



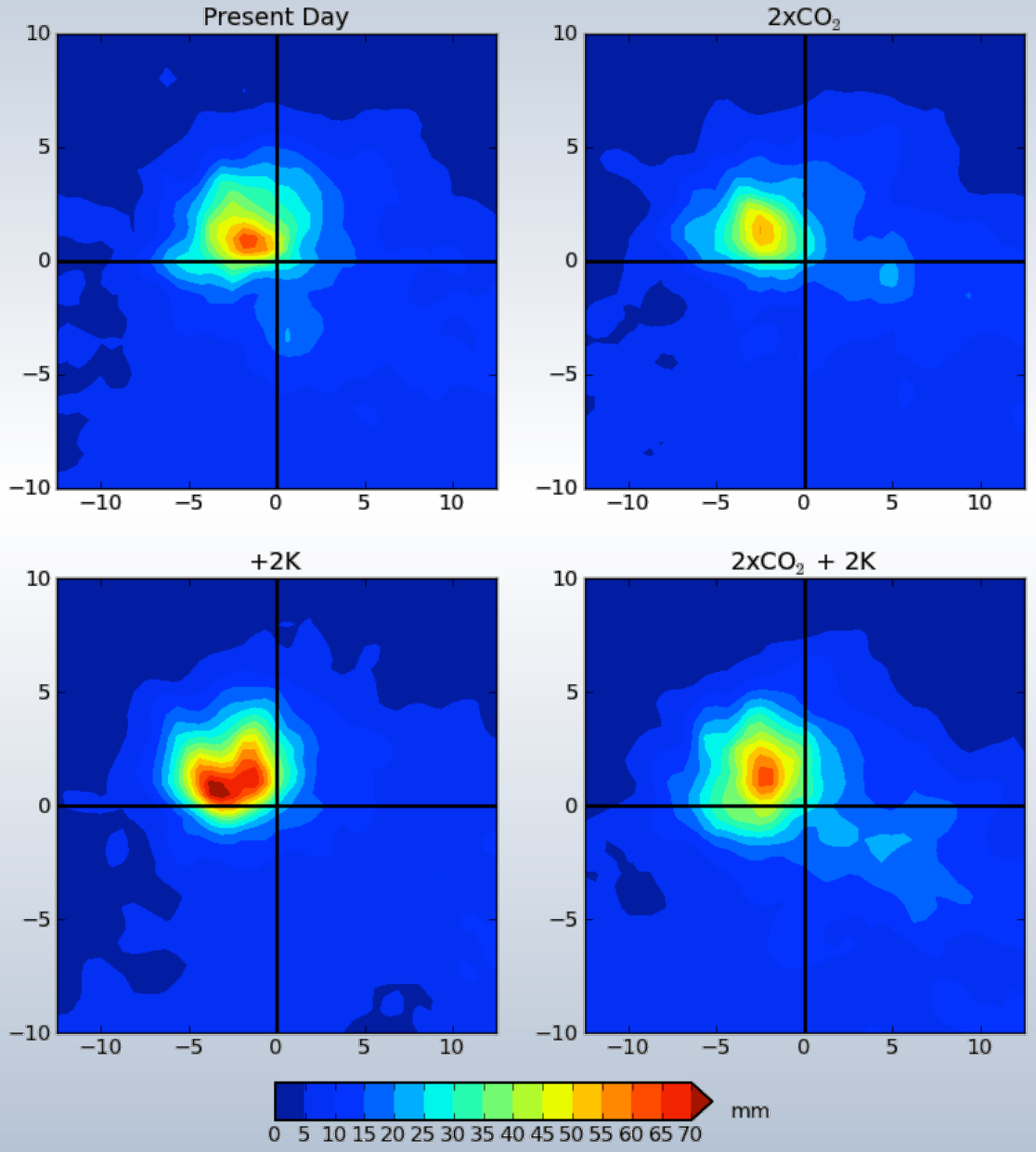
Rainfall Composite: GFDL (ENP)



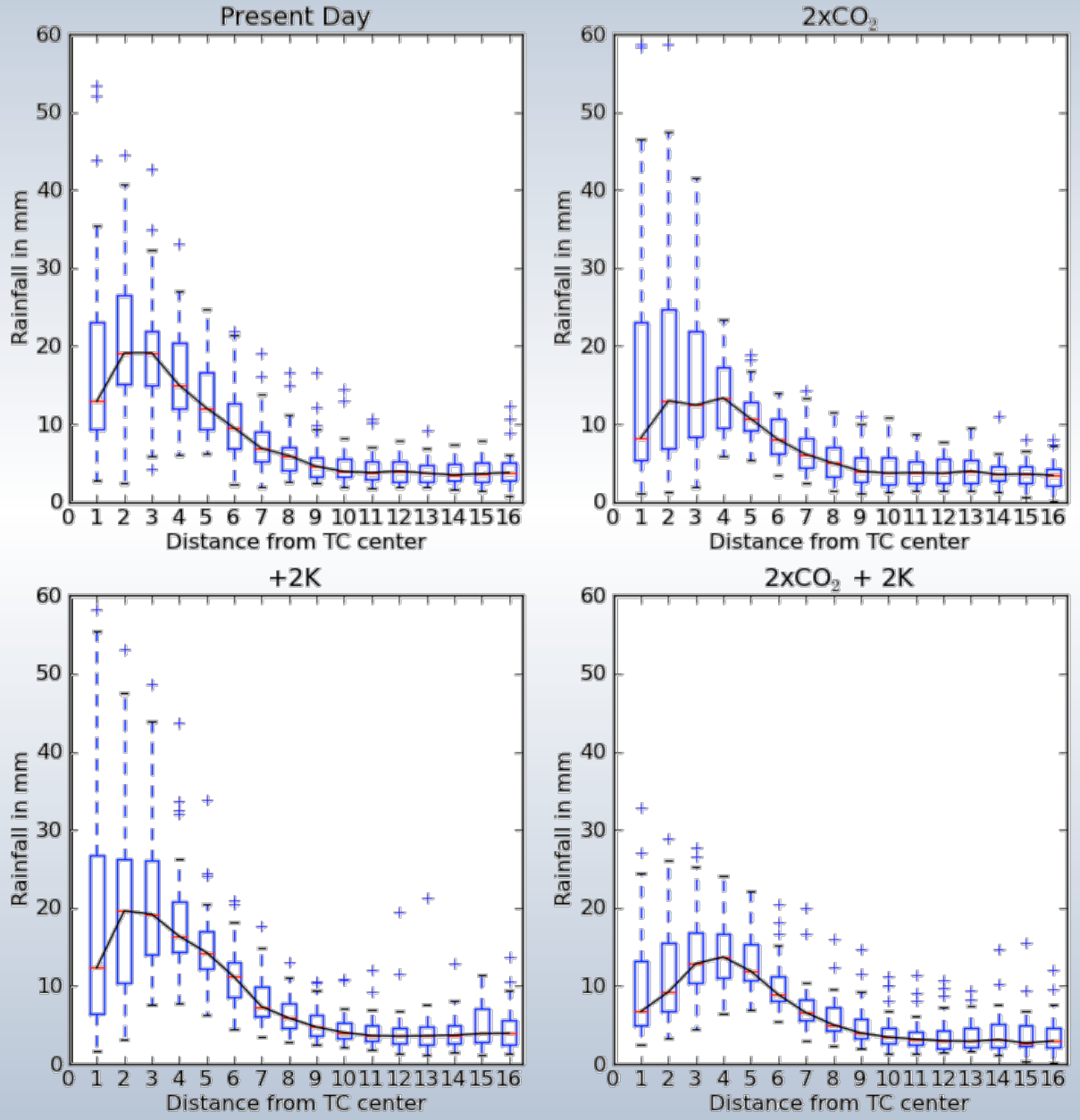
Rainfall Composite: GFDL (WNP)



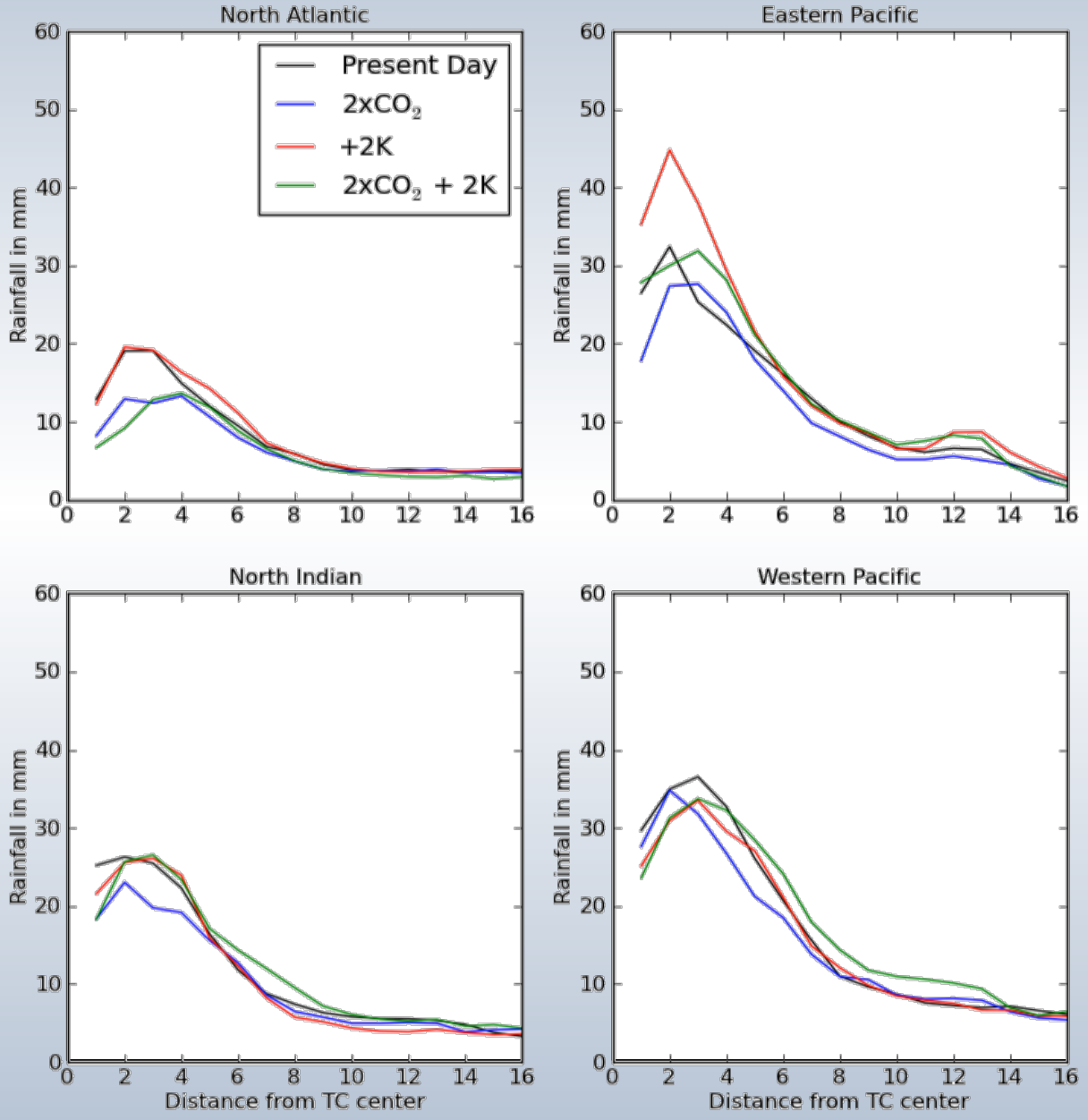
Rainfall Composite: GFDL (NI)



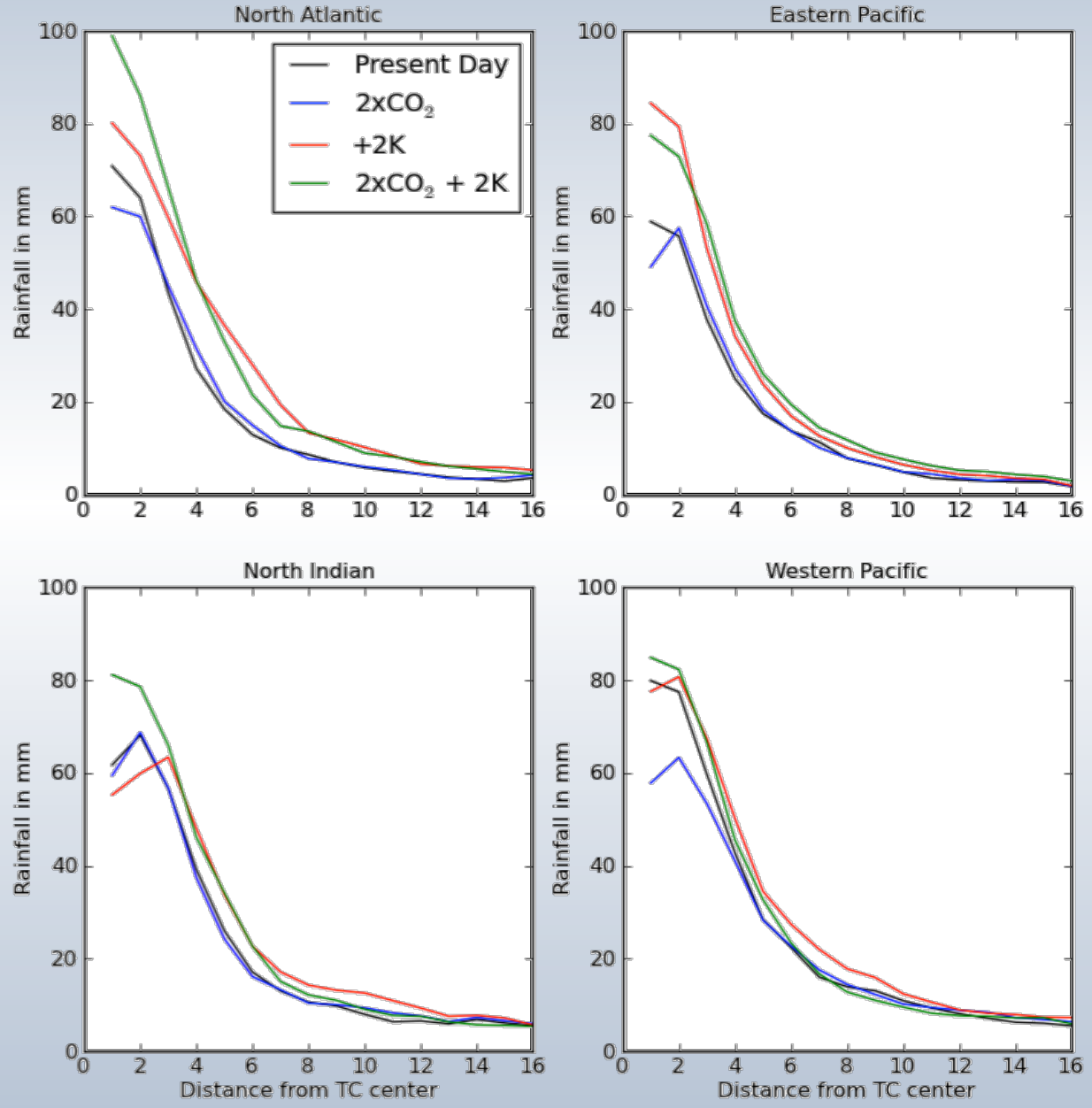
Radial Profile: GFDL (ATL)



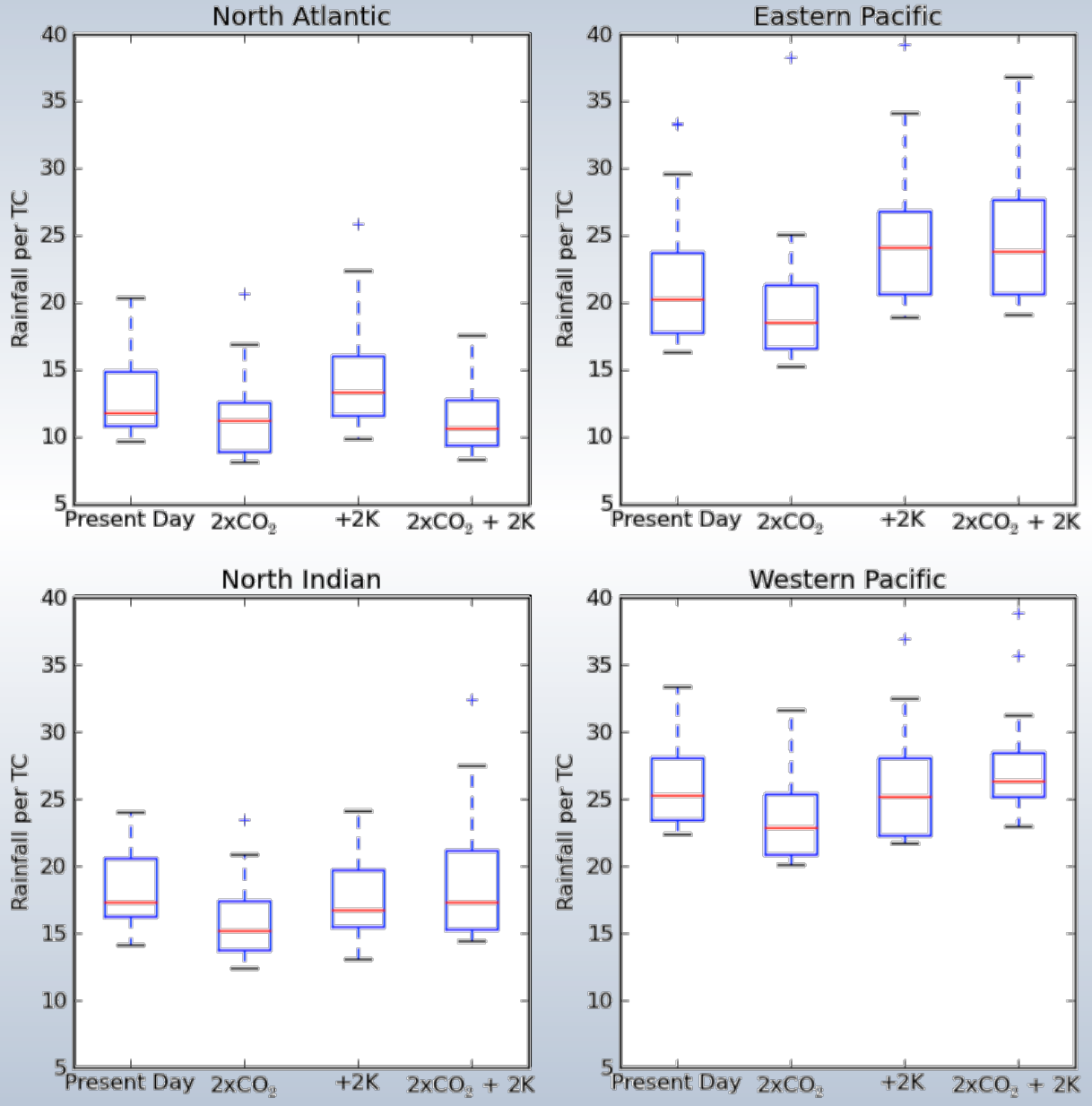
Radial Profile: GFDL



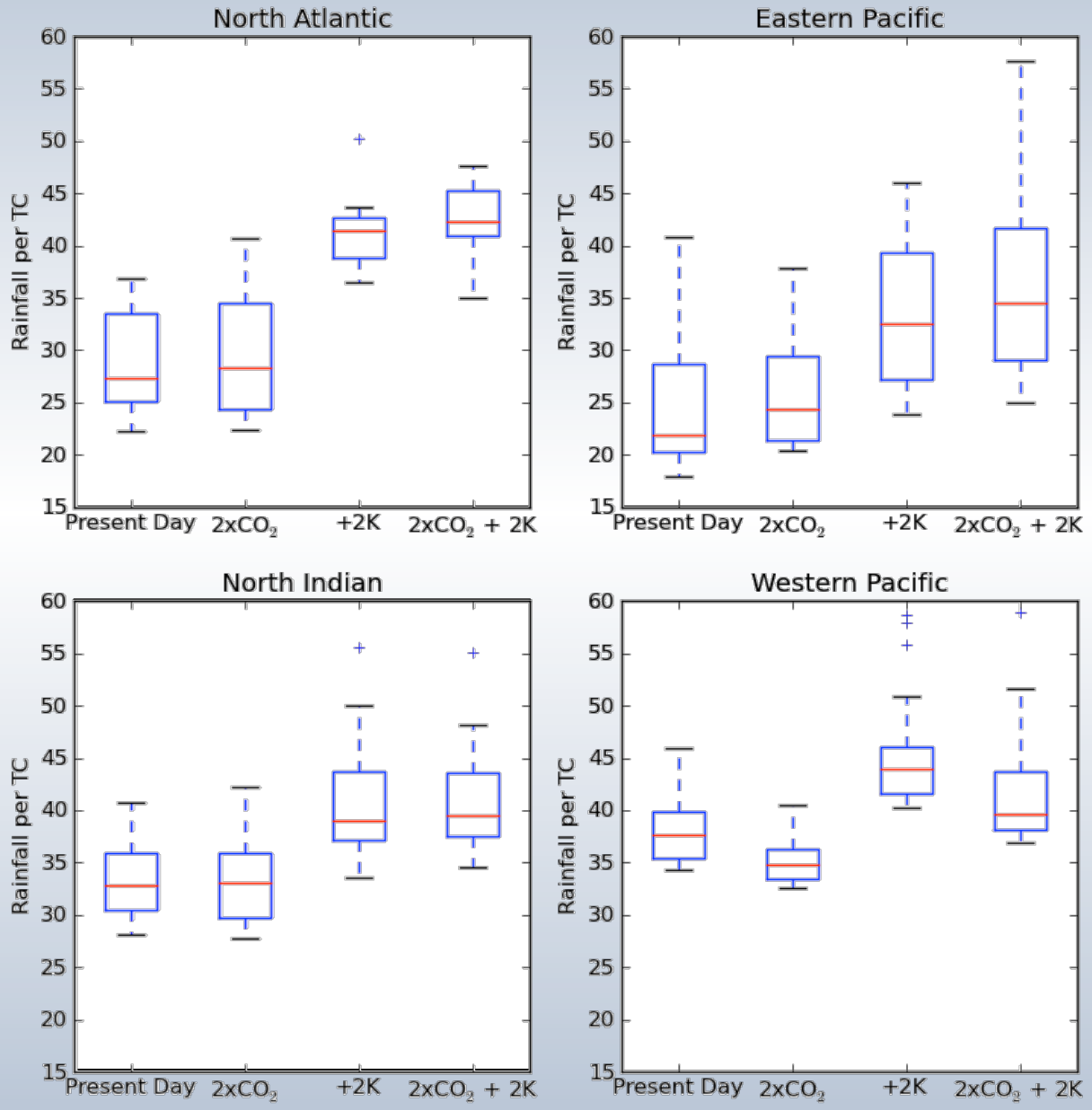
Radial Profile: CMCC



TC Rainfall: GFDL

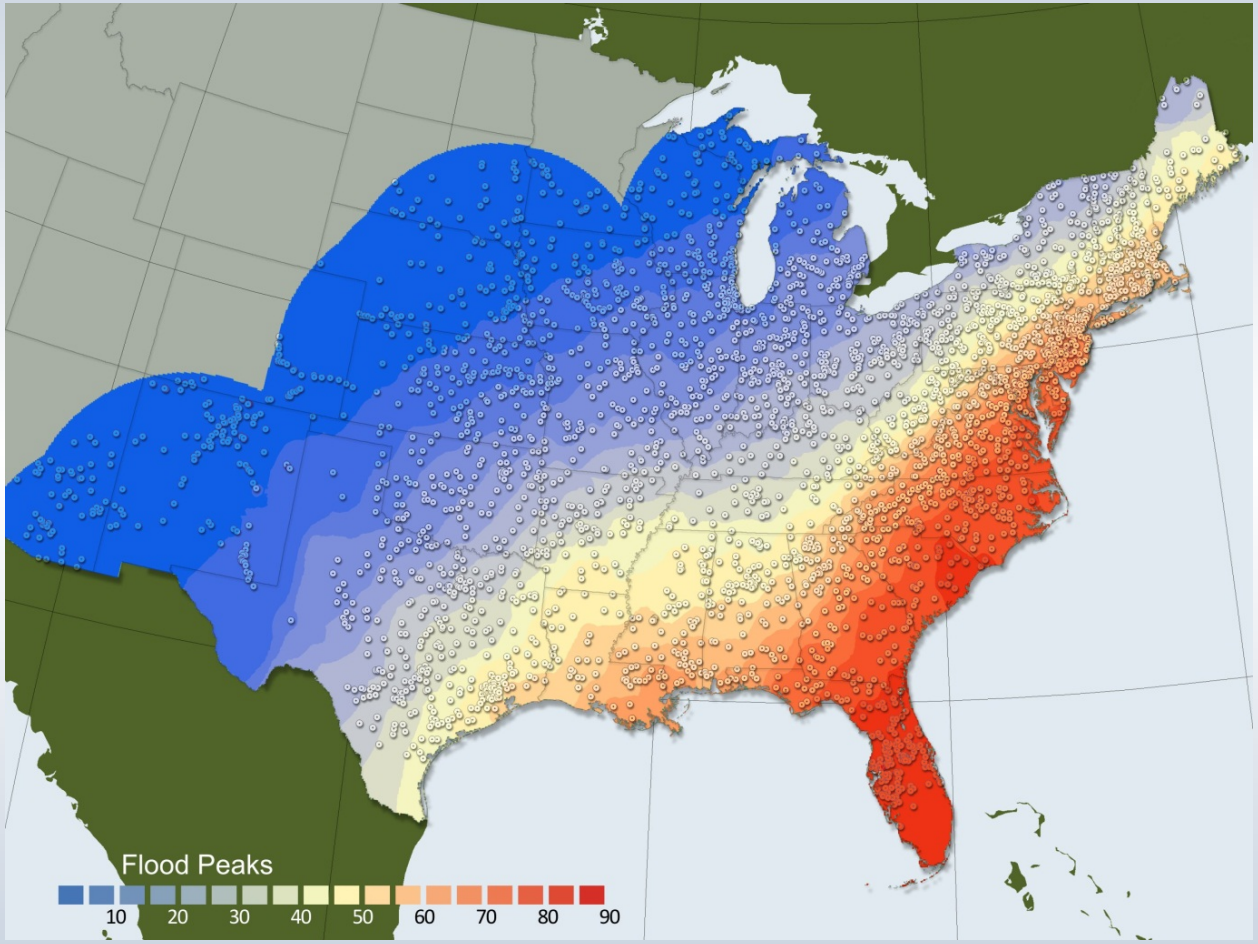


TC Rainfall: CMCC



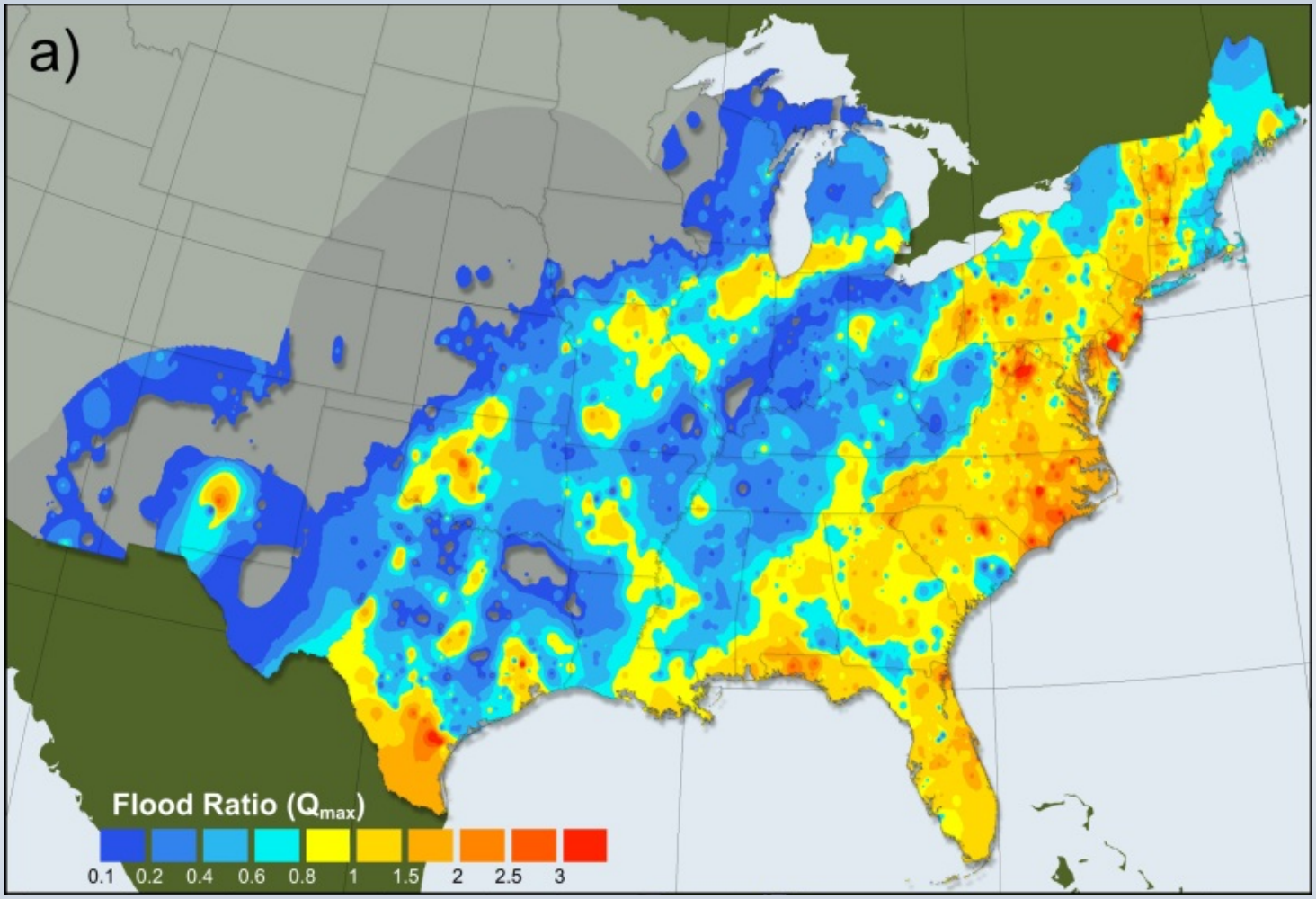
North Atlantic Tropical Cyclones and Flooding

North Atlantic Tropical Cyclone & Flooding



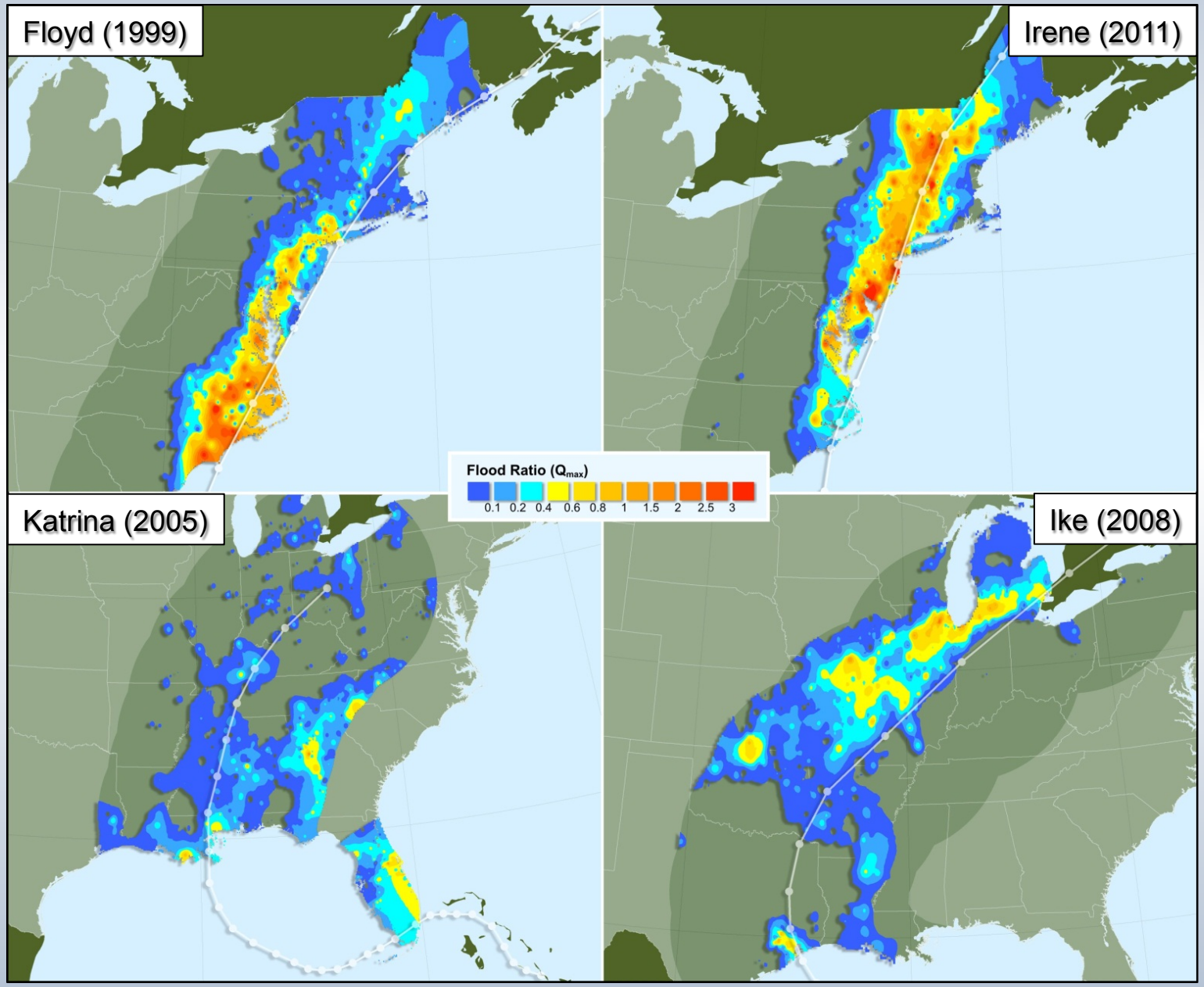
- More than 6500 USGS stations with data over the period 1981-2011.
- Over 100 tropical cyclones passed within 500 km of the study area.
- The tropical cyclone flood peaks are normalized by 10-year flood peak estimated from the 1981-2011 period.

Tropical Cyclone Floods (1981-2011)

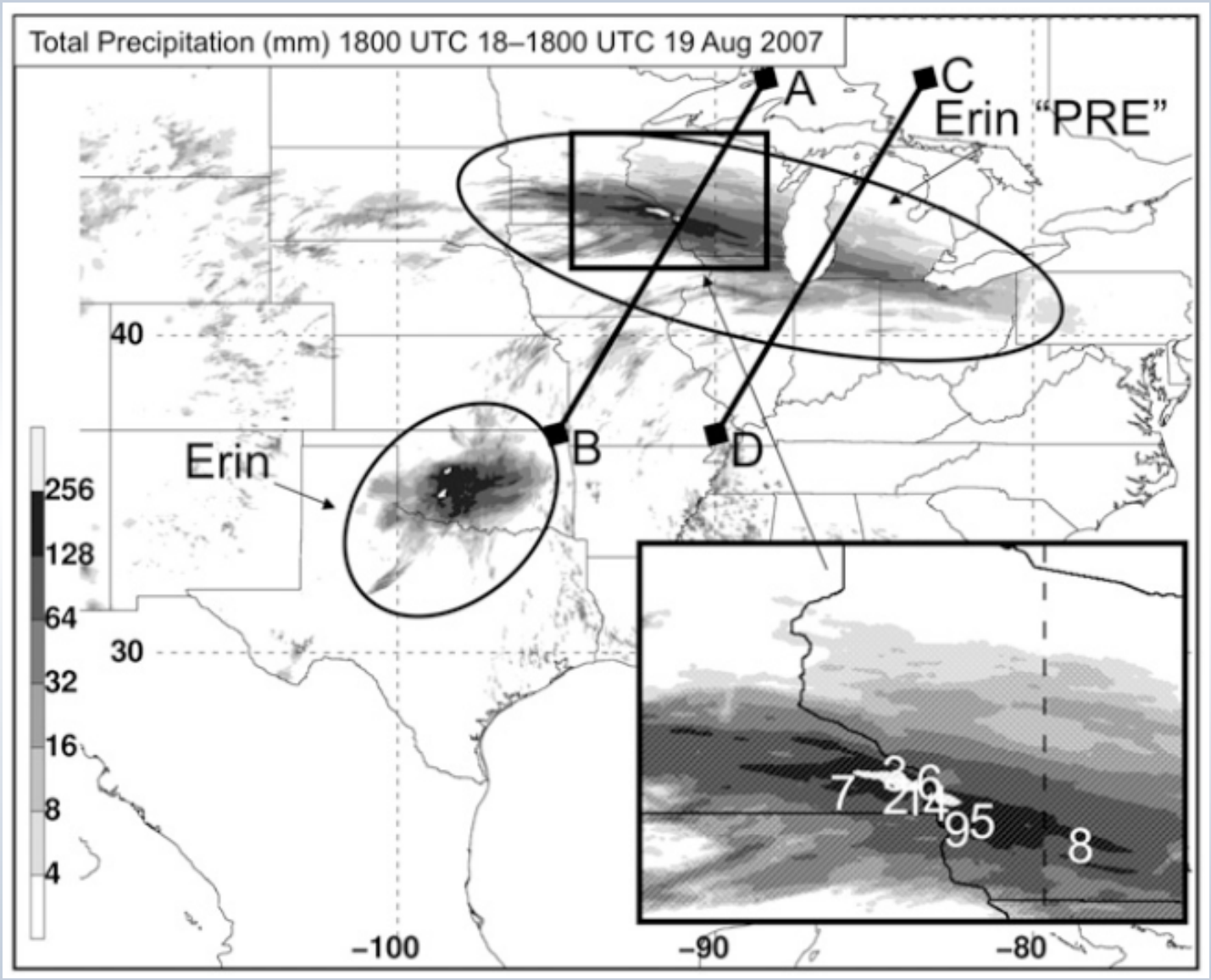


Florida and the eastern seaboard (from South Carolina to Maine and Vermont) are the areas that are the most susceptible to TC floods. Secondary swath over the central United States.

Tropical Cyclone Flood Events

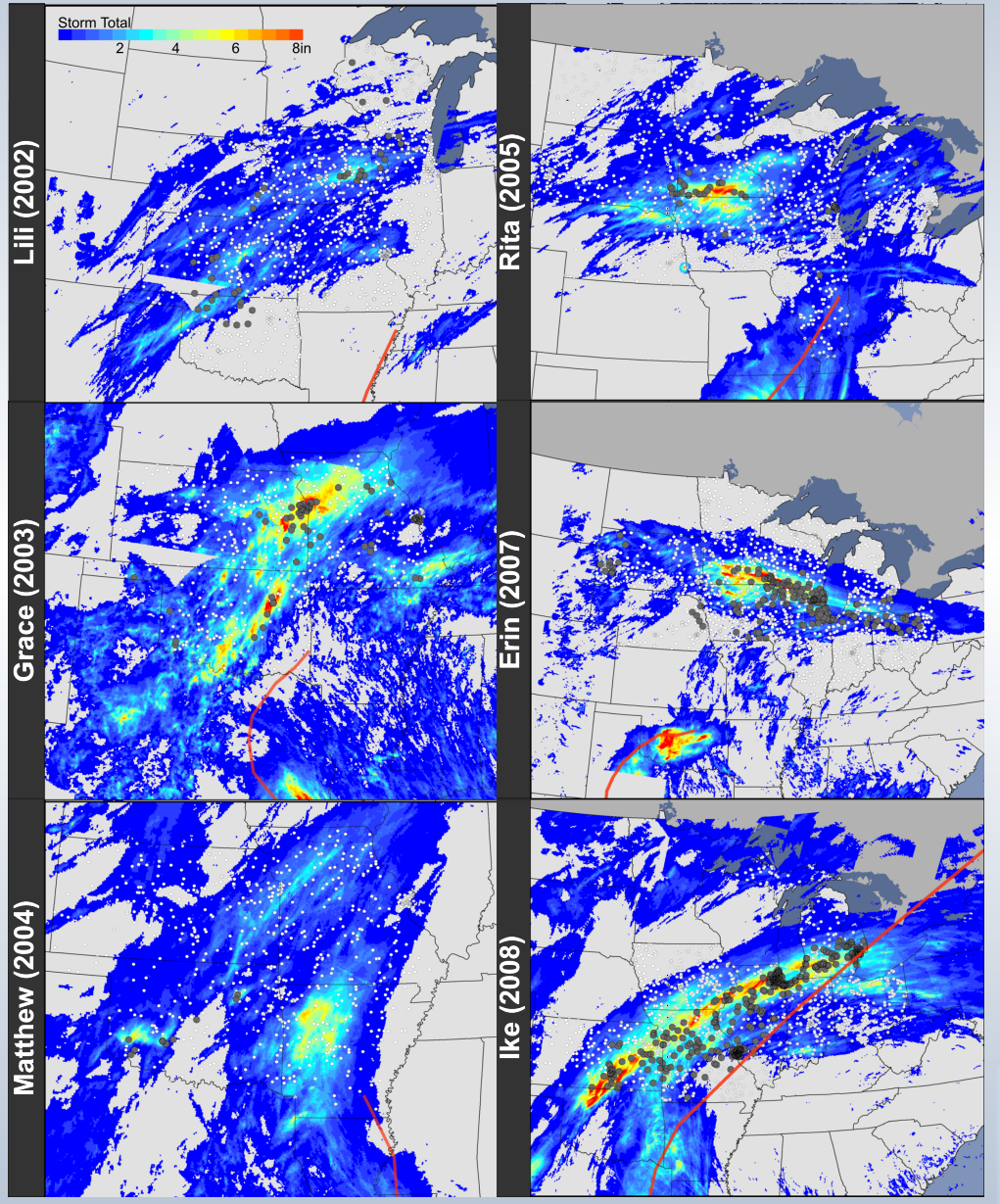


Predecessor (PRE) Rainfall



Galarneau, T.J., L.F. Bosart, R.S. Schumacher, Predecessor rain events ahead of tropical cyclones, *Monthly Weather Review*, 138, 3272–3297, 2010.

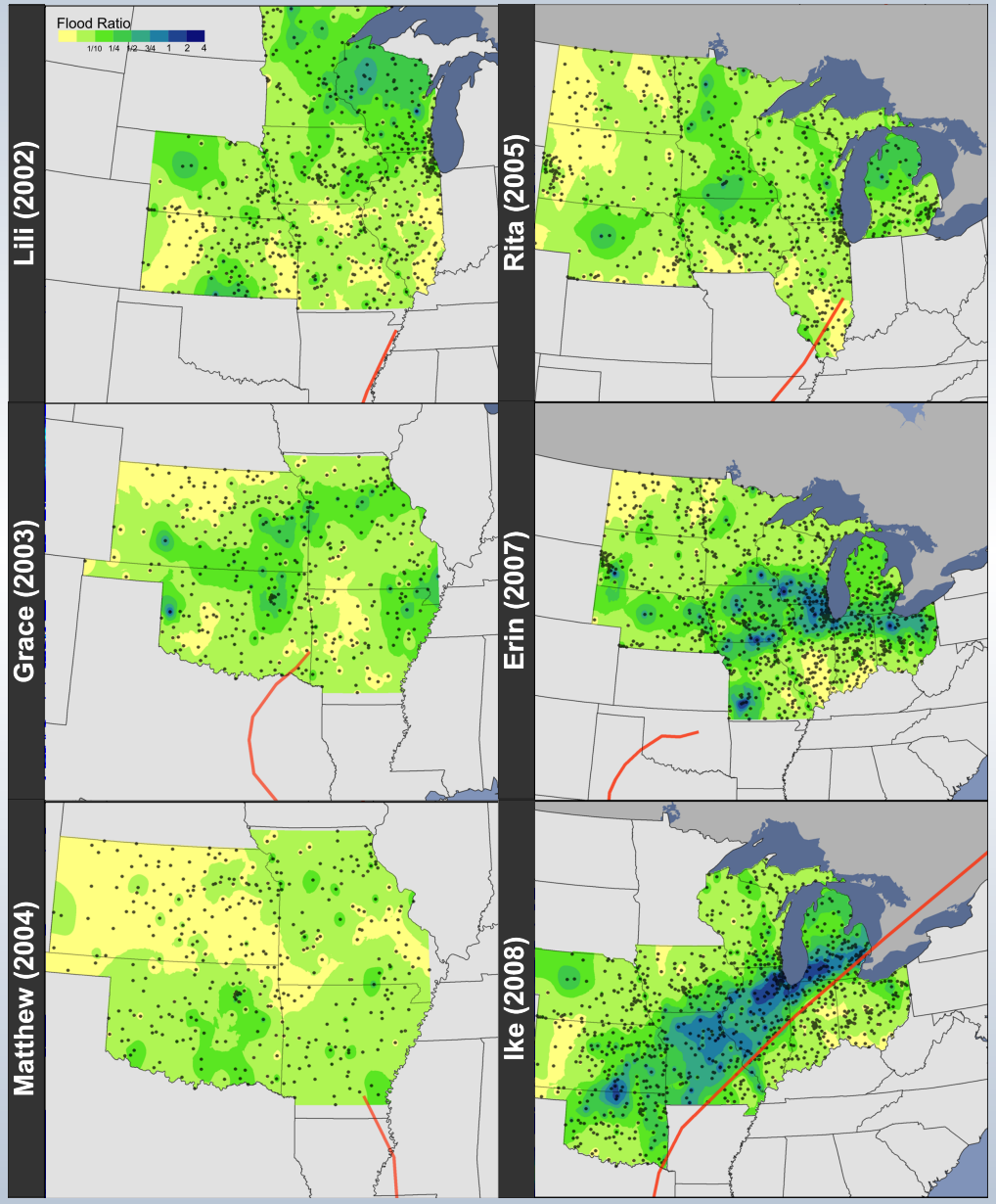
PRE Flooding: Annual Maxima



PREs are responsible for large areas of heavy rainfall, causing annual maximum flood peaks at several locations over the Central US.

Rowe, S.T., and G. Villarini, Flooding associated with predecessor rain events over the Midwest United States, *Environmental Research Letters*, 8, 1-5, 2013 .

PRE Flooding: Regional Perspective



PREs can cause flooding over large areas of the central US. They can also cause flooding in highly urbanized areas, such as Chicago and Detroit.

Conclusions and Future Work

- The rainfall response to doubling CO_2 is weak, while there is a much stronger response to increase in SST.
- The largest differences in rainfall profiles are close to the center of circulation.
- GFDL and CMCC provide generally similar results.
- Tropical cyclones are important flood agents over the United States east of the Rocky Mountains.

Future work

- Extension of these analyses to the Southern Hemisphere
- Comparison of these results with respect to the observational record

Thank You!

The End